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DESCRIPTION

LIQUID FUEL FOR INTERNAL COMBUSTION ENGINE

TECHNICAL FIELD

The present invention relates to improvements in liquid fuels for enabling an efficiency and output substantially equal to or higher than in conventional gasoline without requiring any change in the structure or material of an existing internal combustion engine for gasoline.

BACKGROUND ART

As a part of efforts against recent environmental problems, the problem of air pollution by automobile exhaust gas has been taken more seriously. Therefore, an alcohol-based fuel including alcohols added to light naphtha is drawing attention as a fuel for internal combustion engine usable as a substitute for the conventional gasoline, which can remarkably reduce the concentrations of carbon monoxide (CO) and hydrocarbon (HC) in the automobile exhaust gas, and its practical application has been examined.

Such a synthetic liquid fuel comprising light naphtha and alcohols can preferably reduce SOx and the like also in addition to the carbon monoxide (CO) and hydrocarbon (HC) described above, because alcohols or the like have substantially an extremely small sulfur content, compared with light naphtha or the like. However, the inclusion of the alcohols leads to a problem that contact of a synthetic liquid fuel with metal, particularly, aluminum, aluminum alloy, or the like at high temperature and high pressure in a fuel injection device or the like causes corrosion (elution) of the aluminum, aluminum alloy or the like during long-term use, which may cause a failure.

Focusing attention to the above-mentioned problem, the present invention has an object to provide a liquid fuel for internal combustion engine extremely excellent in practicability, or free from the corrosion (elution) of metal, particularly, aluminum, aluminum alloy or the like by these alcohol-containing synthetic liquid fuels.

DISCLOSURE OF THE INVENTION

To attain the above-mentioned object, the liquid fuel for internal combustion engine of the present invention comprises 2 to 85 wt% of an alcohol component of aliphatic monohydric alcohol having 2 to 6 carbon atoms per molecule per se or a mixture thereof and 15 to 98 wt.% of a hydrocarbon component, in which, when the alcohol component in the liquid fuel for internal combustion engine is N wt.%, water is added thereto in an amount corresponding to the larger of 0.02×N wt.% or more and 0.1 wt.% of the resulting liquid fuel for internal combustion engine.

According to this characteristic, when the alcohol component in the resulting liquid fuel for internal combustion engine is N wt.%, water is added thereto in an amount corresponding to the larger of 0.002×N wt.% or more and 0.1 wt.% of the resulting liquid fuel for internal combustion engine, whereby a liquid fuel for internal combustion engine extremely excellent in practicability, or free from the corrosion (elution) of metal, particularly, aluminum, aluminum alloy or the like, can be obtained.

The liquid fuel for internal combustion engine of the present invention comprises 2 to 85 wt.% of an alcohol component of aliphatic monohydric alcohol having 2 to 6 carbon atoms per molecule per se or a mixture thereof and 15 to 98 wt.% of a hydrocarbon component, in which the resulting liquid fuel for internal combustion engine contains an aluminum corrosion inhibitor in an amount capable of inhibiting the aluminum

corrosion at a predetermined given temperature, and the aluminum corrosion inhibitor comprises at least one member selected from among methanol, glycol hydrocarbons, ketone hydrocarbons, ester hydrocarbons and aldehyde hydrocarbons.

According to this characteristic, at least one member selected from among methanol, glycol hydrocarbons, ketone hydrocarbons, ester hydrocarbons, and aldehyde hydrocarbons is used as the aluminum corrosion inhibitor, whereby not only a liquid fuel for internal combustion engine extremely excellent in practicability, or free from corrosion (elution) of metal, particularly, aluminum, aluminum alloy or the like can be obtained, but also a liquid fuel for internal combustion engine excellent in low-temperature stability, or capable of avoiding the separation between alcohol and hydrocarbon at low temperature can be obtained.

The liquid fuel for internal combustion engine of the present invention preferably contains at least water as the aluminum corrosion inhibitor.

According to this, inexpensive water is used as part of the aluminum corrosion inhibitor, whereby the amount of the relatively expensive aluminum corrosion inhibitor other than water can be minimized to prevent an increase in cost of the resulting liquid fuel for internal combustion engine.

The liquid fuel for internal combustion engine of the present invention preferably further comprises at least one kind of ether components having not more than 12 carbon atoms per molecule and having at least one ether bond in the molecule.

According to this, the inclusion of the ether component can prevent the separation between the alcohol component and the hydrocarbon component in the resulting liquid fuel during long-term storage or the like.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a flowchart showing a process for producing a liquid fuel for internal combustion engine in working examples of the present invention;

Fig. 2 is a graph showing the relation between the ratio of alcohol and hydrocarbon components in the liquid fuel and the concentrations of pollutant gases in exhaust gas;

Fig. 3 is a view showing each composition of formulations of the working examples;

Fig. 4 is a view showing the test result of Formulation 1 of the working examples;

Fig. 5 is a view showing the test result of Formulation 2 of the working examples;

Fig. 6 is a view showing the test result of Formulation 3 of the working examples;

Fig. 7 is a view showing the test result of Formulation 4 of the working examples;

Fig. 8 is a view showing the test result of Formulation 5 of the working examples;

Fig. 9 is a view showing the test result of Formulation 6 of the working examples;

Fig. 10 is a view showing the test result of Formulation 7 of the working examples;

Fig. 11 is a view showing the test result of Formulation 8 of the working examples;

Fig. 12 is a view showing the test result of Formulation 9 of the working examples;

Fig. 13 is a view showing the test result of Formulation 10 of the working examples;

Fig. 14 is a view showing the test result of Formulation 11 of the working examples;

Fig. 15 is a view showing the test result of Formulation 12 of the working examples;

Fig. 16 is a view showing the test result of Formulation 13 of the working examples;

Fig. 17 is a view showing the test result of formulation 14 of the working examples;

Fig. 18 is a view showing the test result of Formulation 15 of the working examples;

Fig. 19 is a view showing the test result of Formulation 16 (Formulation 1+Ether) of the working examples;

Fig. 20 is a view showing the test result of Formulation 17 (Formulation 2+Ether) of the working examples;

Fig. 21 is a view showing the test result of Formulation 18 (Formulation 3+Ether) of the working examples;

Fig. 22 is a view showing the test result of Formulation 19 (Formulation 4+Ether) of the working examples;

Fig. 23 is a view showing the test result of Formulation 20 (Formulation 5+Ether) of the working examples;

Fig. 24 is a view showing the test result of Formulation 21 (Formulation 6+Ether) of the working examples;

Fig. 25 is a view showing the test result of Formulation 22 (Formulation 7+Ether) of the working examples;

Fig. 26 is a view showing the test result of Formulation 23 (Formulation 8+Ether) of the working examples;

Fig. 27 is a view showing the test result of Formulation 24 (Formulation 9+Ether) of the working examples;

Fig. 28 is a view showing the test result of Formulation 25 (Formulation 10+Ether) of the working examples;

Fig. 29 is a view showing the test result of Formulation 26 (Formulation 11+Ether) of the working examples;

Fig. 30 is a view showing the test result of Formulation 27 (Formulation 12+Ether) of the working examples;

Fig. 31 is a view showing the test result of Formulation 28 (Formulation 13+Ether) of the working examples;

Fig. 32 is a view showing the test result of Formulation 29 (Formulation 14+Ether) of the working examples;

Fig. 33 is a view showing the test result of Formulation 30 (Formulation 15+Ether) of the working examples;

Fig. 34 is a view showing the test result of Formulation 0 of the working examples;

Fig. 35 is a view showing the effect of addition of water and aluminum corrosion inhibitor in each formation of the working examples;

Fig. 36 is a view showing the relation between the loading of alcohol and aluminum corrosion; and

Fig. 37 is a view showing a formulation for verifying the minimum loading of water and the result of the verifications.

BEST MODE FOR CARRYING OUT THE INVENTION

With respect to the above-mentioned alcohol, hydrocarbon, and ether used as main raw materials in the present invention and the methanol, glycol hydrocarbons, ketone hydrocarbons, ester hydrocarbons, aldehyde hydrocarbons and water used as the aluminum corrosion inhibitor therein, the content ratios in the resulting synthetic liquid fuel and those suitably usable therein and the reasons thereof will be described, respectively.

As the main raw material alcohol that is a main component of the resulting synthetic liquid fuel, a straight-chain type or non-straight chain type alcohol having 2 to 6 carbon atoms per molecule can be suitably used. As the main raw material alcohol, an alcohol larger in the number of carbon atoms per molecule than ethyl alcohol having 2 carbon atoms per molecule is used to avoid the inclusion of a high proportion of methanol that is an alcohol with remarkably high polarity having one carbon atom, whereby an increase in the entire polarity of the resulting synthetic liquid fuel or swelling of a rubber pipe for fuel supply or the like with the methanol with high polarity can be avoided.

The main raw material alcohols include polyhydric alcohols such as secondary and tertiary alcohols. However, since the high prices and unavailability of such higher alcohols result in an increased cost of the resulting synthetic liquid fuel, primary (monohydric) alcohol is preferably used.

The carbon number of a molecular chain per molecule of such an alcohol is preferably set to not more than 10 and, particularly, to not more than 6 when low temperature is taken into consideration. When the carbon number is 7 or more and, particularly, exceeds 10, the combustion time tends to extend in combustion, in addition to significant deterioration of volatility at normal room temperature or at low temperature, and a difference in combustion rate from the hydrocarbon readily occurs to make the resulting fuel improper as a gasoline alternate fuel.

The main raw material alcohols may be used not only singly but also in proper combination of two or more kinds of different alcohols, depending on price, availability, plant capability, or the like. According to such a combined use of two or more kinds of different alcohols in combination, not only the dispersion of specific gravity of a synthetic fuel resulted from the

dispersion of composition of light naphtha or recycle hydrocarbon used as liquid fuel can be adjusted by properly changing the ratio of these alcohols, but also the combustion rate can be matched to that of gasoline by properly combining these alcohols because their combustion rates are slightly different from each other. Further, such a combined use is preferable from the viewpoint of working in use of gasoline facilities. As the combinations of alcohols, it is preferred to properly combine ethanol, normal propanol (NPA), isopropyl alcohol (IPA), isobutyl alcohol (IBA), butyl alcohol, pentanol, hexanol and the like from the point of price, volatility or the like. Particularly, use of non-straight chain type aliphatic monohydric alcohols is preferred because the resulting octane value can be improved. However, the present invention is never limited by this.

The ratio of the alcohols in the synthetic fuel is preferably set to 85 wt.% or less. As shown in Fig. 2, the carbon monoxide (CO) and hydrocarbon (HC) in exhaust gas are gradually reduced by adding the alcohols to light naphtha that is a gasoline component, and the concentration of hydrocarbon (HC) in exhaust bas becomes substantially constant when the alcohol ratio in the resulting fuel is 25 wt.% or more, while the concentration of carbon monoxide (CO) is gradually reduced up to an alcohol ratio of about 85 wt.%. When the alcohol ratio exceeds about 85 wt.%, the concentrations of carbon monoxide (CO) and hydrocarbon (HC) in exhaust gas become equal to those in the use of an alcohol per se. However, at an alcohol ratio exceeding about 85 wt.%, the combustion rate of the resulting fuel gets close to not the combustion rate of hydrocarbon but the combustion rate of the alcohol, where satisfactory combustion cannot be obtained in a conventional internal combustion engine used for gasoline, causing a disadvantage of improper combustion rate, particularly, in high-speed rotation.

The lower limit value of the alcohol ratio may be set to 2 wt.% or

more, because, when ethanol that is an alcohol is added to light naphtha, as shown in Fig. 36, a weight loss by elution of aluminum is observed in heating at 120°C for 240 hours even in case of a one containing only 2 wt.% of ethanol, and the aluminum corrosion preventive effect of the present invention can be obtained in the inclusion of 2 wt.% or more. Accordingly, the ratio of alcohols in the synthetic fuel can be set in the range of 2 to 85 wt.%, based on the upper limit value described above.

The alcohol ratio can be set, more preferably, in the range of 15 to 75 wt.%, because the result of Fig. 36 shows that an alcohol ratio exceeding 10 wt.% causes a weight loss by elution of aluminum even in heating at 80°C for 240 hours, and the result of Fig. 2 shows an alcohol ratio below 15 wt.% causes a remarkable increase particularly in hydrocarbon (HC) and an alcohol ratio exceeding 75 wt.% may cause a trouble in traveling by an asymmetric phenomenon of combustion because of the difference in combustion rate between hydrocarbon and alcohol described above, depending on the models of internal combustion engines.

Saturated or unsaturated hydrocarbons can be suitably used as the hydrocarbon. However, when the number of carbon atoms contained in a molecule of the hydrocarbon exceeds 13, its volatility is reduced, leading to deterioration of ignitability of an igniter, or increased concentration of CO or HC in exhaust gas by the residue in combustion. Therefore, the hydrocarbon may be properly selected, considering the increased concentration of CO or HC in exhaust gas by the residue of combustion, the ignitability of the igniter, or the like, and saturated or unsaturated hydrocarbons having not more than 9 carbon atoms are preferably used. Among them, light naphtha that is a mixture of saturated hydrocarbons can be suitably used because of its low price.

The light naphtha frequently contains aromatic hydrocarbons such

as B (benzene), T (toluene), and X (xylene). However, a high concentration of the aromatic hydrocarbons may cause a rise in concentration of CO or HC in exhaust gas or discharge of these toxic aromatic hydrocarbons themselves such as B (benzene), T (toluene), and X (xylene) to exhaust gas, similarly to the case of gasoline fuel. Therefore, those with low contents of the aromatic hydrocarbons such as B (benzene), T (toluene) and X (xylene) are preferably used.

The concentration of the sulfur content included in the light naphtha is largely varied depending on the crude source. Since a high concentration of the sulfur content causes an increase in SOx in exhaust gas, the light naphtha is preferably desulfurized so that the sulfur content is 0.01% or less.

In addition to the light naphtha, re-refined oil obtained by distilling recycle oil, obtained by a petrochemical treatment that is a part of recycling treatment of waste plastics, the mass disposal of which has been stranded nowadays, to an initial boiling point of 38-60°C and an end point of 180-220°C can be also used. The re-refined oil enables a further reduction in SOx in exhaust gas because it is desulfurized in the stage of naphtha that is a raw material of plastics.

Such a recycle oil is preferably re-refined to an initial boiling point of 38-60°C and an end point of 180-220 °C for application. When the initial boiling point exceeds 60°C, the startability is remarkably reduced at low temperature or in a cold district, so that startability equal to gasoline cannot be obtained, and when the end point becomes higher than 220°C, the power of an engine cannot be generated through a designed value in high-speed rotation of the engine.

As the ether component, at least one kind of ethers having not more than 12 carbon atoms per molecule and having at least one ether bond in the molecule can be used.

Although the ether component is not always needed, addition of the ether component can preferably prevent the isolation between the hydrocarbon component and the alcohol component by secular change or the like. The ratio of the ether component to be added may be properly selected depending on intended storage stability, although it is varied depending on the ratios and compositions of other components used. The ether ratio can be generally set to 5-30 wt.%. With 5 wt.% or less, the effect of the storage stability is smaller, while, when the ether ratio is 30 wt.% or more, ether odor as fuel is generated, and the volatility is significantly increased, leading to an increased evaporation quantity of the fuel, or an increased loss in storage as the fuel.

As the ether to be blended, any one having an ether bond at least in a molecule can be used. However, when the ether to be used has a large carbon number per molecule, the capability for improving the solubility between alcohol and hydrocarbon is deteriorated in addition to the deterioration of its volatility. Further, since such an ether is expensive and hardly available in an amount as fuel, the carbon number of the ether to be used may be set to not more than 12.

Since the use of an ether having a relatively large carbon number is apt to cause the isolation between hydrocarbon and alcohol as described above, the isolation between hydrocarbon and alcohol by reduction in polarity is preferably avoided by using a one having two or more ether bonds per molecule such as diethylene glycol dimethyl ether or ethylene glycol diethyl ether, or a one having a hydroxy (OH) group in addition to the ether bonds in the molecule such as ethylene glycol monoethyl ether. Further, an isolation preventive effect equal to or higher than that of conventional ethers with low carbon number can be obtained by using the one having a plurality of ether bonds or the hydroxy (OH) group in addition to the ether bonds in

the molecule.

These ethers can be used not only singly but also in combination of an ether with small carbon number and an ether with large carbon number from the point of the volatility and the solubility between hydrocarbon and alcohol.

As the aluminum corrosion inhibitor, methanol, glycol hydrocarbons, ketone hydrocarbons, ester hydrocarbons, aldehyde hydrocarbons and water can be used.

As the glycol hydrocarbons used as the aluminum corrosion inhibitor, ethylene glycol or propylene glycol or the like with relatively small molecular weight can be suitably used, since those with high molecular weight are highly viscous to increase the viscosity of the resulting synthetic fuel.

As the ketone hydrocarbons used as the aluminum corrosion inhibitor, any hydrocarbon having at least one ketone bond per molecule can be used. From the point of the high price or the like of ketone hydrocarbons having many carbon atoms per molecule, acetone, dimethyl ketone, methyl ethyl ketone, diethyl ketone, methyl-n-propyl ketone, methyl isobutyl ketone, acetyl acetone or the like, which has a relatively small number of carbon atoms per molecule, can be suitably used.

As the ester hydrocarbons used as the aluminum corrosion inhibitor, any hydrocarbon having at least one ester bond per molecule can be used. From the point of the high price or the like of ester hydrocarbons having many carbon atoms, methyl formate, ethyl formate, methyl acetate, ethyl acetate or the like, which has a relatively small number of carbon atoms per molecule, can be suitably used.

As the aldehyde hydrocarbons used as the aluminum corrosion inhibitor, any hydrocarbon having at least one aldehyde bond per molecule may be used. From the point of the high price or the like of aldehyde

hydrocarbons having many carbon atoms, acetoaldehyde, propionaldehyde, butylaldehyde or the like, which has a relatively small number of carbon atoms per molecule, can be suitably used.

The loadings of the methanol, glycol hydrocarbons, ketone hydrocarbons, ester hydrocarbons, aldehyde hydrocarbons and water as the aluminum corrosion inhibitor can be set to minimum quantities capable of inhibiting the aluminum corrosion of the resulting synthetic liquid fuel by dry corrosion at a predetermined temperature, e.g., 80-120°C, since these aluminum corrosion inhibitors are expensive than the alcohol and naphtha that are the main raw materials. The loading may be set to 10 wt.% or less at a maximum, although it is varied depending on the kind of aluminum corrosion inhibitors to be used, as described in working examples described later.

[Working Examples]

Fig. 1 is a flowchart showing the process of producing a liquid fuel for internal combustion engine in working examples of the present invention. The liquid fuel for internal combustion engine of the present invention is mainly composed of at least one kind of aliphatic monohydric (primary) alcohols, saturated or unsaturated hydrocarbons, an ether component of ether having not more than 12 carbon atoms per molecule and having an ether bond in the molecule per se or a mixture thereof, and an aluminum corrosion inhibitor (including water). After each of these raw materials is measured to a predetermined weight percentage, the ether with polarity smaller than the aliphatic primary alcohol is inputted and mixed to light naphtha as the hydrocarbon with a relatively large weight ratio and the smallest polarity.

The measured alcohol and aluminum corrosion inhibitor are inputted

and mixed to the mixture of light naphtha and ether.

After inputting the alcohol and the aluminum corrosion inhibitor, the specific gravity of the mixed liquid fuel is measured. If the specific gravity is not more than a predetermined specific gravity of 0.735 or more, the alcohol may be properly added to adjust the specific gravity to 0.755.

Formulation examples of fuel compositions prepared in the working examples according to the above-mentioned process are described below. In this example, as shown in Fig. 3, various basic formulations were prepared by combining with the ratio of the alcohol to be added to the naphtha. The methanol, glycol hydrocarbons, ketone hydrocarbons, ester hydrocarbons, aldehyde hydrocarbons and water as various aluminum corrosion inhibitors were then added to each basic formulation, respectively, to prepare formulations, and an aluminum corrosion test was carried out for each formation by dipping aluminum in each formulation and heating to a predetermined high temperature. Further, the low-temperature stability of each formulation was evaluated depending on the presence/absence of separation of fuel at a low temperature (−10°C in this example).

The result of the aluminum corrosion test and the result of the evaluation of storage stability at normal-temperature and low temperature for the cases of adding the aluminum corrosion inhibitors to each formulation are described based on Figs. 4 to 34.

The test method for elution (weight loss) of aluminum and the test method for storage stability are as follows.

<Aluminum Elution Test>

(1) Predetermined quantities of a sample fuel and water (distilled water) were weighted, respectively, in an SUS-made ball mill pot (300 ml), totaling 100 ml.

(2) A pure aluminum sample piece (A1050) is dipped in the pot of (1),

and about 5 flaws are given to the aluminum sample piece by a file as it is dipped in the sample fuel (in order to remove the oxide film on the surface of the aluminum sample piece).

(3) The atmospheric gas of the ball mil pot is replaced by nitrogen, and quickly capped.

(4) The resulting ball mill pot is put in a constant temperature dryer set to a predetermined temperature of 80 to 120°C.

(5) After the lapse of a predetermined time, the ball mill pot is taken out and allowed to cool in a draft.

(6) The weight loss of the aluminum sample piece is measured, and when even a slight weight loss by partial discoloration or pitting is observed, 1 is described even if the weight loss is less than 0.

<Storage Stability Test>

After blending fuels, the state of the fuels after leaving at room temperature for 1 hour and the state of the fuels after storing in a refrigerator (−11°C) followed by leaving for one day were observed, respectively. Those mutually solved were evaluated as 100, and those clouded or causing a separation of fuels as 0.

E-2 that is Formulation Example 0 has a basic composition consisting of 98 wt.% of naphtha and 2 wt.% of ethanol, in which only ethanol is used as the alcohol with the least ratio causing the aluminum corrosion. Even a formulation with a minimum alcohol ratio as E-2 causes a weight loss by aluminum corrosion by dry corrosion, as shown in Fig. 34, when heated at 120°C for 120 hours.

When 0.1 wt.% of water is added to E2, the weight loss by aluminum corrosion at 120°C is eliminated, and the corrosion resistance is improved. When water is further added in 0.2 wt.% and 0.4 wt.%, the layer separation occurs at −10°C in 0.2 wt.%-addition, and further even at room

temperature in 0.4 wt.%-addition, while those free from water or those with 0.1 wt.% of water have no problem for storage property at −10°C that is low temperature. Accordingly, the addition of water is effective for the aluminum corrosion, but the storage stability is deteriorated by the addition of water.

The result of addition of methanol instead of the water is shown in designation of formulation "E2-Me" of Fig. 34. In the case of addition of methanol, the aluminum corrosion resistance is improved in 0.5 wt.%-addition. Further, those with addition of 0.5 wt.% of methanol cause no layer separation at room temperature or at lower temperature, and the normal-temperature and low-temperature storage properties are improved by adding the methanol. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

The result of addition of ethylene glycol as the glycols instead of the water is shown in designation of formulation "E2-PG" of Fig. 34. In the case of addition of ethylene glycol, the aluminum corrosion resistance is improved in the same 0.5 wt.%-addition as the methanol, in which satisfactory aluminum corrosion resistance is obtained even at 120°C, and normal-temperature and low-temperature storage properties can be improved by adding the ethylene glycol without causing the layer separation at room temperature or at low temperature. Thus, the ethylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

The result of addition of acetone as the ketones instead of water and the result of addition thereof in combination with water are shown in designation of formulation "E2-Ac" of Fig. 34. In the case of single addition of acetone without water, satisfactory aluminum corrosion resistance at 120°C and satisfactory results for normal-temperature stability and low-temperature stability are obtained in 2.0 wt.%-addition. Thus, the

acetone can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of acetone in combination with water shown in "E2-Ac" of Fig. 34, by using acetone with water, satisfactory aluminum corrosion resistance and satisfactory results for normal-temperature stability and low-temperature stability can be obtained even if the loading of acetone is minimized. Further, by blending the acetone, satisfactory low-temperature storage property can be obtained even in a case containing water of 0.2 wt.%, with which the low-temperature storage property cannot be obtained in the addition of water per se. Accordingly, the acetone has the effect of improving the low-temperature stability, and the water has the effect of reducing the loading of the acetone.

The result of single addition of ethyl formate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "E2-GE" of Fig. 34. In the case of single addition of ethyl formate without water, satisfactory aluminum corrosion resistance at 120°C and satisfactory results for normal-temperature stability and low-temperature stability are obtained in 2.0 wt.%-addition. Thus, the ethyl formate can be satisfactorily used as the aluminum corrosion inhibitor.

From the result of addition of ethyl formate in combination with water shown in "E2-GE" of Fig. 34, by using the ethyl formate in combination with water, satisfactory aluminum corrosion resistance and satisfactory results for normal-temperature stability and low-temperature stability can be obtained even if the loading of ethyl formate is minimized. Further, by blending the ethyl formate, satisfactory low-temperature storage property can be obtained even in a case containing water of 0.2 wt.%, with which the low-temperature storage property cannot be obtained in the addition of water per se. Accordingly, the ethyl formate has the effect of improving the

low-temperature stability, and the water has the effect of reducing the loading of the ethyl formate.

The result of single addition of butylaldehyde as the aldehydes instead of water and the result of addition thereof in combination with water are shown in designation of formulation "E2-BA" of Fig. 34. In the case of single addition of butylaldehyde without water, satisfactory aluminum corrosion resistance at 120°C and satisfactory results for normal-temperature-stability and low-temperature stability are obtained in 1.5 wt.% addition. Thus, the butylaldehyde can be satisfactorily used as the aluminum corrosion inhibitor.

From the result of addition of butylaldehyde in combination with water shown in "E2-BA" of Fig. 34, by using the butylaldehyde in combination with water, satisfactory aluminum corrosion resistance and satisfactory results for normal-temperature stability and low-temperature stability can be obtained even if the loading of butylaldehyde is minimized. Further, by blending the butylaldehyde, satisfactory low-temperature storage property can be obtained even in a case containing water of 0.2 wt.%, with which the low-temperature storage property cannot be obtained in the addition of water per se. Accordingly, the butylaldehyde has the effect of improving the low-temperature stability, and the water has the effect of reducing the loading of the butylaldehyde.

E-10 that is Formulation Example 1 has a basic composition consisting of 90 wt.% of naphtha and 10 wt.% of ethanol, in which only ethanol is used as the alcohol with a relatively small ratio. Even a formulation with a relatively small alcohol ratio as E-10, as shown in Fig. 4, causes a weight loss by aluminum corrosion by dry corrosion when heated at 100°C for 120 hours or at 120°C for 24 hours, similarly to the corrosion result at 80°C for 240 hours shown in the above-mentioned aluminum corrosion

test (Fig. 36).

When water is added to E10 to 0.1 wt.% at 100 °C and to 0.4% at 120°C, the weight loss by aluminum corrosion is eliminated, and the corrosion resistance is improved. However, the layer separation occurs in a storage property test at −10°C when water is added to 0.4 wt.%, with which the weight loss by aluminum corrosion occurs at 120°C, and the layer separation also occurs even at room temperature in 0.5 wt.%-addition of water, where water is excessively added by 0.1 wt.% in order to give a tolerance to the corrosion preventing performance, while those free from water or those with 0.1 wt.% of water have no problem for storage property at −10°C that is low temperature. Accordingly, the addition of water is effective for the aluminum corrosion by dry corrosion, but the storage stability is deteriorated by the addition of water when it is intended to ensure satisfactory aluminum corrosion preventive performance at 120°C that is high temperature by use of water.

The result of addition of methanol instead of the water is shown in designation of formulation “E10-Me” of Fig. 4. In the case of addition of methanol, the aluminum corrosion resistance is improved in substantially the same 0.4 wt.%-addition as the water, in which satisfactory aluminum corrosion resistance can be obtained even at 100°C, and the low-temperature stability is improved without causing the layer separation, compared with the case with 0.4 wt.% of water. Further, in 0.5 wt.%-addition of methanol, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the methanol without causing the layer separation at room temperature or at low temperature. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

The result of addition of propylene glycol as the glycols instead of the

water is shown in designation of formulation "E10-PG" of Fig. 4. In the case of addition of propylene glycol, the aluminum corrosion resistance is improved in substantially the same 0.4 wt.%-addition as the water, in which satisfactory aluminum corrosion resistance can be obtained even at 100°C, and the low-temperature stability is improved without causing the layer separation, compared with the case with 0.4 wt.% of water. In 0.5 wt.%-addition of propylene glycol, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the propylene glycol without causing the layer separation at room temperature or at low temperature. Thus, the propylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

The result of addition of diethyl ketone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "E10-DEK" of Fig. 4. In the case of single addition of diethyl ketone without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 3.5 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 4.5 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature stability and the low-temperature stability in both the formulations. Thus, the diethyl ketone can be satisfactory used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of diethyl ketone in combination with water shown in "E10-DEK" of Fig. 4, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition

of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the diethyl ketone. Accordingly, the diethyl ketone is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of ethyl formate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation “E10-GE” of Fig. 4. In the case of single addition of ethyl formate without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 3.0 wt.%-addition, and satisfactory aluminum corrosion at resistance 120°C is obtained in 4.0 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature stability and the low-temperature stability in both the formulations. Thus, the ethyl formate can be satisfactory used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of ethyl formate in combination with water shown in “E10-GE” of Fig. 4, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the ethyl formate. Accordingly, the ethyl formate is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of propionaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation “E10-PA” of Fig. 4. In the case of single addition of propionaldehyde without water, satisfactory

aluminum corrosion resistance at 100°C is obtained in 1.5 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 2.0 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature stability and the low-temperature stability in both the formulations. Thus, the propionaldehyde can be satisfactory used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of propionaldehyde in combination with water shown in "E10-PA" of Fig. 4, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the propionaldehyde. Accordingly, the propionaldehyde is effective for reducing the loading of water and for improving the low-temperature stability.

With respect to "E10-E" that is a basic formulation comprising ethers in addition to E10, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, propylene glycol, diethyl ketone, ethyl formate, and propionaldehyde in the same manner as in E10. The results are shown in Fig. 19. As is apparent form the results shown in Fig. 19, the same effect as in the case of E10 is obtained also in the addition of ethers. Accordingly, the water, methanol, propylene glycol, diethyl ketone, ethyl formate and propionaldehyde can be effectively used also in those including the ethers.

E20 that is Formation Example 2 has a basic composition composed of 80 wt.% of naphtha and 20 wt.% of ethanol, in which the content of ethanol as the alcohol is increased more than in E10 of Formation Example 1. In

E20, as shown in Fig. 5, the weight loss by aluminum corrosion is increased at 100°C and at 120°C more than that in the above E10 according to the rise of alcohol ratio. This shows that the increase in alcohol tends to facilitate occurrence of dry corrosion, increasing the weight loss by aluminum corrosion.

When water is added to E20 to 0.1 wt.% at 100 °C and to 0.9 wt.% at 120°C, for example, the weight loss by aluminum corrosion is eliminated, as shown in Fig. 5, and the corrosion resistance is improved. However, the layer separation occurs in a low-temperature storage property test at −10°C when water is added to 0.9 wt.%, with which no weight loss by aluminum corrosion occurs at 120°C, and the layer separation also occurs even at room temperature in 1.1 wt.%-addition of water, while those free from water or those with 0.1 wt.% of water have no problem for storage property at −10°C that is low temperature. Accordingly, the addition of water is effective for the aluminum corrosion by dry corrosion, but the storage stability is deteriorated by the addition of water when it is intended to ensure satisfactory aluminum corrosion preventive performance at 120°C that is high temperature by use of water.

The result of addition of methanol instead of the water is shown in designation of formulation "E20-Me" of Fig. 5. In the case of addition of methanol, the aluminum corrosion resistance is improved in 0.5 wt.%-addition, in which satisfactory aluminum corrosion resistance can be obtained even at 120°C, and the low-temperature stability is also satisfactory. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

The result of addition of ethylene glycol as the glycols instead of the water is shown in designation of formulation "E20-EG" of Fig. 5. In the case of addition of ethylene glycol, the aluminum corrosion resistance is improved

in the same 0.5 wt.%-addition as the methanol, in which satisfactory aluminum resistance can be obtained even at 120°C, and the low-temperature stability is also satisfactory. Thus, the ethylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

The result of addition of acetone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "E20-Ac" of Fig. 5. In the case of single addition of acetone without water, satisfactory aluminum corrosion resistance at 100°C can be obtained in 3.0 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C can be obtained in 4.0 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature stability and the low-temperature stability in both the formulations. Thus, the acetone can be satisfactory used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of acetone in combination with water shown in "E20-Ac" of Fig. 5, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be also improved by further adding the acetone. Accordingly, the acetone is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of methyl formate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "E20-GM" of Fig. 5. In the case of single addition of methyl formate without water, satisfactory aluminum corrosion resistance at 100°C can be obtained in 6.0 wt.%-addition, and

satisfactory aluminum corrosion resistance at 120°C can be obtained in 8.0 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature stability and the low-temperature stability in both the formulations. Thus, the methyl formate can be satisfactory used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl formate in combination with water shown in "E20-GM" of Fig. 5, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be also improved by further adding the methyl formate. Accordingly, the methyl formate is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of butylaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "E20-BA" of Fig. 5. In the case of single addition of butylaldehyde without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 2.0 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 2.5 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature stability and the low-temperature stability in both the formulations. Thus, the butylaldehyde can be satisfactory used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of butylaldehyde in combination with water shown in "E20-BA" of Fig. 5, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced,

and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be also improved by further adding the butylaldehyde. Accordingly, the butylaldehyde is effective for reducing the loading of water and for improving the low-temperature stability.

With respect to "E20-E" that is a basic formulation comprising ethers in addition to E20, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, ethylene glycol, acetone, methyl formate, and butylaldehyde in the same manner as in E20. The results are shown in Fig. 20. From the results shown in Fig. 20, the same effect as in the case of E20 is obtained even in the addition of ethers. Thus, the water, methanol, ethylene glycol, acetone, methyl formate and butylaldehyde can be effectively used also in those including the ethers.

E50 that is Formation Example 3 has a basic composition composed of 50 wt.% of naphtha and 50 wt.% of ethanol, in which the content of ethanol as the alcohol is increased further more than in E20 of Formation Example 2. In E50, as shown in Fig. 6, the weight loss by aluminum corrosion is increased at 100°C and at 120°C more than that in the case of E20 according to the rise of alcohol ratio. This shows that the increase in alcohol tends to facilitate occurrence of dry corrosion to increase the weight loss by aluminum corrosion.

When water is added to E50 to 0.1 wt.% at 100 °C and to 3.4 wt.% at 120°C, for example, the weight loss by aluminum corrosion is eliminated, as shown in Fig. 6, and the corrosion resistance is improved. However, the layer separation occurs in a low-temperature storage property test at −10°C when water is added to 3.4 wt.%, with which no weight loss by aluminum

corrosion occurs at 120°C, and the layer separation also occurs even at room temperature in 3.6 wt.%-addition of water, while those free from water or those with 0.1 wt.% of water have no problem for storage property at −10°C that is low temperature. Accordingly, the addition of water is effective for the aluminum corrosion by dry corrosion, but the storage stability is deteriorated by the addition of water when it is intended to ensure satisfactory aluminum corrosion preventive performance also at 120°C that is high temperature by use of water.

The result of addition of methanol instead of the water is shown in designation of formulation "E50-Me" of Fig. 6. In the case of addition of methanol, the aluminum corrosion resistances at 100°C and 120°C are improved in 0.8 wt.%-addition and in 1.0 wt.%-addition, respectively, in which the low-temperature stability is also satisfactory. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

The result of addition of ethylene glycol as the glycols instead of the water is shown in designation of formulation "E50-EG" of Fig. 6. In the case of addition of ethylene glycol, the aluminum corrosion resistance is improved in substantially the same 0.7 wt.%-addition as the methanol, and the aluminum corrosion resistance at 120°C is also improved in 1.0 wt.%-addition, in which the low-temperature stability is also satisfactory. Thus, the ethylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

The result of addition of methyl ethyl ketone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "E50-MEK" of Fig. 6. In the case of single addition of methyl ethyl ketone without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 4.0 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 6.0

wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the methyl ethyl ketone can be satisfactory used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl ethyl ketone in combination with water shown in "E50-MEK" of Fig. 6, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be also improved by further adding the methyl ethyl ketone. Accordingly, the methyl ethyl ketone is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of ethyl formate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "E50-GE" of Fig. 6. In the case of single addition of ethyl formate without water, satisfactory aluminum corrosion resistances at 100°C and at 120°C are obtained in 6.0 wt.%-addition and in 10.0 wt.%-addition, respectively. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the ethyl formate can be satisfactory used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of ethyl formate in combination with water shown in "E50-GE" of Fig. 6, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels.

Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be also improved by further adding the methyl formate. Accordingly, the methyl formate is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of acetaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "E50-AA" of Fig. 6. In the case of single addition of the acetaldehyde without water, satisfactory aluminum corrosion resistances at 100°C and at 120°C are obtained in 3.0 wt.%-addition and in 4.0 wt.%-addition, respectively. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the acetaldehyde can be satisfactory used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of acetaldehyde in combination with water shown in "E50-AA" of Fig. 6, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be also improved by further adding the acetaldehyde. Accordingly, the acetaldehyde is effective for reducing the loading of water and for improving the low-temperature stability.

With respect to "E50-E" that is a basic formulation comprising ethers in addition to E50, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, ethylene glycol, methyl ethyl ketone, ethyl formate, and acetaldehyde in the same manner as in the

case of E50. The results are shown in Fig. 21. As is apparent from the results shown in Fig. 21, the same effect as in the case of E50 can be obtained also in the case of addition of ethers. Thus, the water, methanol, ethylene glycol, methyl ethyl ketone, ethyl formate and acetaldehyde can be effectively used also in those including the ethers.

IN40 that is Formation Example 4 has a basic composition composed of 60 wt.% of naphtha, 20 wt.% of isopropyl alcohol, and 20 wt.% of n-butanol, in which two kinds of alcohols, or isopropyl alcohol and n-butanol which are larger in carbon number than ethanol, are used as the alcohol. In IN40, also, the same weight loss by aluminum corrosion by dry corrosion as in the case of E50 is observed, as shown in Fig. 7.

When water is added to IN40 to 0.1 wt.% at 90 °C and to 3.6 wt% at 120°C, for example, the weight loss by aluminum corrosion is eliminated, as shown in Fig. 7, and the corrosion resistance is improved. However, the layer separation occurs in a low-temperature storage property test at −10°C when water is added to 3.6 wt.%, with which no weight loss by aluminum corrosion occurs at 120°C, and the layer separation also occurs even at room temperature in 3.8 wt.%-addition of water, while those free from water or those with 0.1 wt.% of water have no problem for storage property at −10°C that is low temperature. Accordingly, the addition of water is effective for the aluminum corrosion by dry corrosion, but the storage stability is deteriorated by the addition of water when it is intended to ensure satisfactory aluminum corrosion preventive performance also at 120°C that is high temperature by use of water.

The result of addition of methanol instead of the water is shown in designation of formulation "IN40-Me" of Fig. 7. In the case of addition of methanol, satisfactory aluminum corrosion resistance is obtained even at 100°C in 0.8 wt.%-addition, in which the low temperature stability is also

satisfactory. Further, in 1.7 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the methanol without causing the layer separation at room temperature or at low temperature. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methanol in combination with water shown in "IN40-Me" of Fig. 7, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels is also improved by further adding the methanol. Accordingly, the methanol is effective for reducing the loading of water and for improving the low-temperature stability.

The result of addition of ethylene glycol as the glycols instead of the water is shown in designation of formulation "IN40-EG" of Fig. 7. In the case of addition of ethylene glycol, the aluminum corrosion resistance is improved in 1.5 wt.%-addition, in which satisfactory aluminum corrosion resistance can be obtained even at 100°C, and the low-temperature stability is also satisfactory. Further, in 3.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the ethylene glycol without causing the layer separation at room temperature or at low temperature. Thus, the ethylene glycol can be satisfactory used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of ethylene glycol in

combination with water shown in "IN40-EG" of Fig. 7, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the ethylene glycol has the effect of reducing the loading of water.

The result of addition of acetone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formation "IN40-Ac" of Fig. 7. In the case of single addition of acetone without water, satisfactory aluminum corrosion resistances at 100°C and 120°C and satisfactory results for normal-temperature stability and low-temperature stability are obtained in 0.2 wt.%-addition. Thus, the acetone can be satisfactory used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of acetone in combination with water shown in "IN40-Ac" of Fig. 7, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be also improved by further adding the acetone. Accordingly, the acetone is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of methyl formate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "IN40-GM" of Fig. 7. In the case of single addition of methyl formate without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 1.5 wt.%-addition, and

satisfactory aluminum corrosion resistance at 120°C is obtained in 3.0 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature stability and the low-temperature stability in both the formulations. Thus, the methyl formate can be satisfactory used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl formate in combination with water shown in "IN40-GM" of Fig. 7, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be also improved by further adding the methyl formate. Accordingly, the methyl formate is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of butylaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "IN40-BA" of Fig. 7. In the case of single addition of butylaldehyde without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.3 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 0.5 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature stability and the low-temperature stability in both the formulations. Thus, the butylaldehyde can be satisfactory used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of butylaldehyde in combination with water shown in "IN40-BA" of Fig. 7, satisfactory aluminum corrosion resistance can be obtained even if the loading of water is reduced,

and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the butylaldehyde has the effect of reducing the loading of water.

With respect to "IN40-E" that is a basic formulation comprising ethers in addition to IN40, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, ethylene glycol, acetone, methyl formate, and butylaldehyde in the same manner as in the case of IN40. The results are shown in Fig. 22. From the results shown in Fig. 22, the same effect as in the case of IN40 can be obtained also in the case of addition of ethers, and the water, methanol, ethylene glycol, acetone, methyl formate and butylaldehyde can be effectively used also in those including the ethers.

IN15 that is Formation Example 5 has a basic composition composed of 85 wt.% of naphtha, 10 wt.% of isopropyl alcohol, and 5 wt.% of n-butanol, in which the alcohol ratio is smaller than in the case of "IN40".

When water is added to IN15 to 0.1 wt.% at 90 °C and to 0.6 wt.% at 120°C, for example, the weight loss by aluminum corrosion is eliminated, as shown in Fig. 8, and the corrosion resistance is improved. However, the layer separation occurs in a low-temperature storage property test at −10°C when water is added to 0.6 wt.%, with which no weight loss by aluminum corrosion occurs at 120°C, and the layer separation also occurs even at room temperature in 0.8 wt.%-addition of water, while those free from water or those with 0.1 wt.% of water have no problem for the storage property at −10°C that is low temperature. Accordingly, the addition of water is effective for the aluminum corrosion by dry corrosion, but the storage stability is deteriorated by the addition of water when it is intended to ensure satisfactory aluminum corrosion preventive performance also at

120°C that is high temperature by use of water.

The result of addition of methanol instead of the water is shown in designation of formulation "IN15-Me" of Fig. 8. In the case of addition of methanol, satisfactory aluminum corrosion resistance can be obtained even at 100°C in 0.5 wt.%-addition, in which the low-temperature stability is also satisfactory. In 1.5 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the methanol without causing the layer separation at room temperature or at low temperature. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methanol in combination with water shown in "IN15-Me" of Fig. 8, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be also improved by further adding the methanol. Accordingly, the methanol is effective for reducing the loading of water and for improving the low-temperature stability.

The result of addition of propylene glycol as the glycols instead of the water is shown in designation of formulation "IN15-PG" of Fig. 8. In the case of addition of propylene glycol, the aluminum corrosion resistance is improved in 2.0 wt.%-addition, in which satisfactory aluminum corrosion resistance can be obtained even at 100°C, and the low-temperature stability is also satisfactory. In 4.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the

normal-temperature and low-temperature storage properties can be improved by adding the propylene glycol without causing the layer separation at room temperature or at low temperature. Thus, the propylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of propylene glycol in combination with water shown in "IN15-PG" of Fig. 8, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the propylene glycol has the effect of reducing the loading of water.

The result of addition of methyl isobutyl ketone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "IN15-MBK" of Fig. 8. In the case of single addition of methyl isobutyl ketone without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.3 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 0.5 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the methyl isobutyl ketone can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl isobutyl ketone in combination with water shown in "IN15-MBK" of Fig. 8, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the

same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be also improved by further adding the methyl isobutyl ketone. Accordingly, the methyl isobutyl ketone is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of ethyl formate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "IN15-GE" of Fig. 8. In the case of single addition of ethyl formate without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 1.0 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 5.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the ethyl formate can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of ethyl formate in combination with water shown in "IN15-GE" of Fig. 8, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be also improved by further adding the ethyl formate. Accordingly, the ethyl formate has the effect of reducing the loading of water and for improving the low-temperature stability.

The result of addition of propionaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "IN15-PA" of Fig. 8. In the case of

single addition of propionaldehyde without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.2 wt.%-addition thereof, and satisfactory aluminum corrosion resistance at 120°C is obtained in 0.4 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature and low-temperature stabilities in both the formulations. Thus, the propionaldehyde can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of propionaldehyde in combination with water shown in "IN15-PA" of Fig. 8, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the propionaldehyde has the effect of reducing the loading of water.

With respect to "IN15-E" that is a basic formulation comprising ethers in addition to IN15, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, propion glycol, methyl isobutyl ketone, ethyl formate, and propionaldehyde in the same manner as in the case of IN15. The results are shown in Fig. 23. As is apparent from the results shown in Fig. 23, the same effect as in the case of IN15 can be obtained also in the case of addition of ethers, and the water, methanol, propion glycol, methyl isobutyl ketone, ethyl formate and propionaldehyde can be effectively used also in those including the ethers.

IN75 that is Formation Example 6 has a basic composition composed of 25 wt.% of naphtha, 35 wt.% of isopropyl alcohol, and 40 wt.% of n-butanol, in which the alcohol ratio is larger than in the above "IN15". In IN75, also, the same weight loss by aluminum corrosion by dry corrosion as in the case of IN15 is observed as shown in Fig. 9.

Even if 0.1 wt.% of water is added to IN75 at 90 °C, satisfactory aluminum corrosion resistance cannot be obtained because the total quantity of alcohols included in the fuel is as large as about 75 wt.%. When water is added in an amount of 0.2 wt.% that is a value exceeding 0.15 wt.% obtained by multiplying the total alcohol quantity by 0.002, satisfactory aluminum corrosion resistance is obtained. Further, at a temperature of 120°C, satisfactory aluminum corrosion resistance at 120°C can be obtained when water is added to 0.8 wt.%. Thus, the addition of water is effective for the aluminum corrosion by dry corrosion.

The result of addition of methanol instead of the water is shown in designation of formulation "IN75-Me" of Fig. 9. In the case of addition of methanol, satisfactory aluminum corrosion resistance can be obtained even at 100°C in 1.0 wt.%-addition, in which the low-temperature stability is also satisfactory. In 2.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the methanol without causing the layer separation at room temperature or at low temperature. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methanol in combination with water shown in "IN75-Me" of Fig. 9, by mixing methanol with water, satisfactory aluminum corrosion preventive performance can be ensured with a smaller content of methanol, and satisfactory storage stability can be ensured both at room temperature and at low temperature. Accordingly, the water is effective for reducing the loading of methanol.

The result of addition of ethylene glycol as the glycols instead of the water is shown in designation of formulation "IN75-EG" of Fig. 9. In the case of addition of ethylene glycol, the aluminum corrosion resistance is

improved in 3.0 wt.%-addition, in which satisfactory aluminum corrosion resistance can be obtained even at 100°C, and the low-temperature stability is also satisfactory. In 6.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the ethylene glycol without causing the layer separation at room temperature or at low temperature. Thus, the ethylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of ethylene glycol in combination with water shown in "IN75-EG" of Fig. 9, by mixing ethylene glycol with water, satisfactory aluminum corrosion preventive performance can be ensured with a smaller content of ethylene glycol, and satisfactory storage stability can be ensured both at room temperature and at low temperature. Accordingly, the water is effective for reducing the loading of ethylene glycol.

The result of addition of methyl-n-propyl ketone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "IN75-MPK" of Fig. 9. In the case of single addition of methyl-n-propyl ketone without water, satisfactory aluminum corrosion resistances at 100°C and 120°C are obtained in 0.2 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the methyl-n-propyl ketone can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl-n-propyl ketone in combination with water shown in "IN75-MPK" of Fig. 9, by mixing methyl-n-propyl ketone with water, satisfactory aluminum corrosion preventive performance can be ensured with a smaller content of

methyl-n-propyl ketone, and satisfactory stability can be ensured both at room temperature and at low temperature. Accordingly, the water is effective for reducing the loading of methyl-n-propyl ketone.

The result of single addition of ethyl formate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "IN75-GE" of Fig. 9. In the case of single addition of ethyl formate without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 2.0 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 3.5 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature and low-temperature stabilities in both the formulations. Thus, the ethyl formate can be satisfactorily used as the aluminum corrosion inhibitor.

From the result of addition of ethyl formate in combination with water shown in "IN75-GE" of Fig. 9, by mixing ethyl formate with water, satisfactory aluminum corrosion preventive performance can be ensured with a smaller content of ethyl formate, and satisfactory storage stability can be ensured both at room temperature and at low temperature. Thus, the water is effective for reducing the loading of ethyl formate.

The result of addition of acetaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "IN75-AA" of Fig. 9. In the case of single addition of acetaldehyde without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.3 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 0.6 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the acetaldehyde can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of acetaldehyde in combination with water shown in "IN75-AA" of Fig. 9, by mixing acetaldehyde with water, satisfactory aluminum corrosion preventive performance can be obtained with a smaller content of acetaldehyde, and satisfactory storage stability can be also obtained both at room temperature and at low temperature. Thus, the water is effective for reducing the loading of acetaldehyde.

With respect to "IN75-E" that is a basic formulation comprising ethers in addition to IN75, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, ethylene glycol, methyl-n-propyl ketone, ethyl formate, and acetaldehyde in the same manner as in IN75. The results are shown in Fig. 24. As is apparent from the results shown in Fig. 24, the same effect as in the case of IN75 can be obtained also in the case of addition of ethers, and the water, methanol, ethylene glycol, methyl-n-propyl ketone, ethyl formate and acetaldehyde can be effectively used also in those including the ethers.

Next, EIB40 that is Formation Example 7 has a basic composition composed of 60 wt.% of naphtha, 20 wt.% of ethanol, and 20 wt.% of isobutyl alcohol, in which the alcohols used are differed from the formation of IN40. In EIB40, also, the same weight loss by aluminum corrosion by dry corrosion as in the above-mentioned E50 and IN40 is observed as shown in Fig. 10.

When water is added to EIB40 to 0.1 wt.% at 90 °C and to 4.8 wt.% at 120°C, for example, the weight loss by aluminum corrosion is eliminated, as shown in Fig. 10, and the corrosion resistance is improved. However, the layer separation occurs in a low-temperature storage property test at −10°C when water is added to 4.8 wt.%, with which no weight loss by aluminum corrosion occurs at 120°C, and the layer separation also occurs even at room temperature in 5.1 wt.%-addition of water, while those free from water or

those with 0.1 wt.% of water have no problem for the storage property at −10°C that is low temperature. Accordingly, the addition of water is effective for the aluminum corrosion by dry corrosion, but the storage stability is deteriorated by the addition of water when it is intended to ensure satisfactory aluminum corrosion preventive performance also at 120°C that is high temperature by use of water.

The result of addition of methanol instead of the water is shown in designation of formulation "EIB40-Me" of Fig. 10. In the case of addition of methanol, satisfactory aluminum corrosion resistance is obtained even at 100°C in 1.5 wt.%-addition, in which the low-temperature stability is also satisfactory. In 2.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the methanol without causing the layer separation at room temperature or at low temperature. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methanol in combination with water shown in "EIB40-Me" of Fig. 10, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the methanol has the effect of reducing the loading of water.

The result of addition of ethylene glycol as the glycols instead of the water is shown in designation of formulation "EIB40-EG" of Fig. 10. In the case of addition of ethylene glycol, the aluminum corrosion resistance is improved in 1.0 wt.%-addition, in which satisfactory aluminum corrosion resistance is obtained even at 100°C, and the low-temperature stability is

also satisfactory. In 2.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the ethylene glycol without causing the layer separation at room temperature or at low temperature. Thus, the ethylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of ethylene glycol in combination with water shown in "EIB40-EG" of Fig. 10, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the ethylene glycol has the effect of reducing the loading of water.

The result of addition of acetone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIB40-Ac" of Fig. 10. In the case of single addition of acetone without water, the aluminum corrosion resistance is improved in 0.2 wt.%-addition, in which satisfactory aluminum corrosion resistance is obtained even at 100°C, and the low-temperature stability is also satisfactory. Further, in 3.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and satisfactory results can be obtained also for normal-temperature stability and low-temperature stability without causing the layer separation at room temperature or at low temperature. Thus, the acetone can be satisfactorily used as the aluminum corrosion inhibitor.

From the result of addition of acetone in combination with water shown in "EIB40-Ac" of Fig. 10, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this

reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the acetone. Accordingly, the acetone is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of methyl formate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIB40-GM" of Fig. 10. In the case of single addition of methyl formate without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 2.5 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 5.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the methyl formate can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl formate in combination with water shown in "EIB40-GM" of Fig. 10, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the methyl formate. Accordingly, the methyl formate is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of butylaldehyde as the aldehydes

instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIB40-BA" of Fig. 10. In the case of single addition of butylaldehyde without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.6 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 1.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the butylaldehyde can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of butylaldehyde in combination with water shown in "EIB40-BA" of Fig. 10, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the butylaldehyde. Accordingly, the butylaldehyde is effective for reducing the loading of water and improving the low-temperature stability.

With respect to "EIB40-E" that is a basic formulation comprising ethers in addition to EIB40, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, ethylene glycol, acetone, methyl formate, and butylaldehyde in the same manner as in the case of EIB40. The results are shown in Fig. 25. As is apparent from the results shown in Fig. 25, the same effect as in the case of EIB40 is obtained also in the case of addition of ethers, and the water, methanol, ethylene glycol, acetone, methyl formate and butylaldehyde can be effectively used also in those including the ethers.

EIB15 that is Formation Example 8 has a basic composition composed of 85 wt.% of naphtha, 5 wt.% of ethanol, and 10 wt.% of isobutyl alcohol, in which the alcohols used are differed from those used in the formations of the above-mentioned IN15. In EIB15, also, the same weight loss by aluminum corrosion by dry corrosion as in the cases of E10 and IN15 is observed as shown in Fig. 11.

When water is added to EIB15 to 0.1 wt.% at 90 °C, and to 0.6 wt.% at 120°C, the weight loss by aluminum corrosion is eliminated, as shown in Fig. 11, and the corrosion resistance is improved. However, the layer separation occurs in a storage property test at −10°C when water is added to 0.6 wt.%, with which no weight loss by aluminum corrosion occurs at 120°C, and the layer separation also occurs even at room temperature in 0.8 wt.%-addition of water, while those free from water or those with 0.1 wt.% of water have no problem for the storage property at −10°C that is low temperature. Accordingly, the addition of water is effective for the aluminum corrosion by dry corrosion, but the storage stability is deteriorated by the addition of water when it is intended to ensure satisfactory aluminum corrosion preventive performance also at 120°C that is high temperature by use of water.

The result of addition of methanol instead of the water is shown in designation of formulation "EIB15-Me" of Fig. 11. In the case of addition of methanol, the aluminum corrosion resistance is improved in 1.0 wt.%-addition, in which satisfactory aluminum corrosion resistance can be obtained even at 100°C, and the low-temperature stability is also satisfactory. In 1.5 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the methanol without causing the layer separation at room temperature or at low

temperature. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methanol in combination with water shown in "EIB15-Me" of Fig. 11, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the methanol has the effect of reducing the loading of water. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the methanol. Thus, the methanol is effective for reducing the loading of water and for improving the low-temperature stability.

The result of addition of propylene glycol as the glycols instead of the water is shown in designation of formulation "EIB15-PG" of Fig. 11. In the case of addition of propylene glycol, the aluminum corrosion resistance is improved in 1.5 wt.%-addition, in which satisfactory aluminum corrosion resistance is obtained even at 100°C, and the low-temperature stability is also satisfactory. In 3.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and normal-temperature and low-temperature storage properties can be improved by adding the propylene glycol without causing the layer separation at room temperature or at low temperature. Thus, the propylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of propylene glycol in combination with water shown in "EIB15-PG" of Fig. 11, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to

improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the propylene glycol has the effect of reducing the loading of water.

The result of addition of diethyl ketone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIB15-DEK" of Fig. 11. In the case of single addition of diethyl ketone without water, the aluminum corrosion resistance is improved in 1.0 wt.%-addition, in which satisfactory aluminum corrosion resistance is obtained even at 100°C, and the low-temperature stability is also satisfactory. In 1.5 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature stability and the low-temperature stability are also satisfactory without causing the layer separation at room temperature or at low temperature. Thus, the diethyl ketone can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of diethyl ketone in combination with water shown in "EIB15-DEK" of Fig. 11, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the diethyl ketone. Accordingly, the diethyl ketone is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of methyl acetate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIB15-SM" of Fig. 11. In the case of

single addition of methyl acetate without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 2.0 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 3.0 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature stability and low-temperature stability in both the formulations. Thus, the methyl acetate can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl acetate in combination with water shown in "EIB15-SM" of Fig. 11, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding methyl acetate. Thus, the methyl acetate is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of propionaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIB15-PA" of Fig. 11. In the case of single addition of propionaldehyde without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.6 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 1.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the acetaldehyde can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of propionaldehyde in

combination with water shown in "EIB15-PA" of Fig. 11, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the propionaldehyde has the effect of reducing the loading of water.

With respect to "EIB15-E" that is a basic formulation comprising ethers in addition to EIB15, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, propylene glycol, diethyl ketone, methyl acetate, and propionaldehyde in the same manner as in the case of EIB15. The results are shown in Fig. 26. As is apparent from the results shown in Fig. 26, the same effect as in the case of EIB15 can be obtained also in the case of addition of ethers, and the water, methanol, propylene glycol, diethyl ketone, methyl acetate and propionaldehyde can be effectively used also in those including the ethers.

EIB75 that is Formation Example 9 has a basic composition composed of 25 wt.% of naphtha, 35 wt.% of ethanol, and 40 wt.% of isobutyl alcohol, in which the alcohol ratio is increased, compared with EIB40. In EIB75, also, the same weight loss by aluminum corrosion by dry corrosion as in the case of EIB40 is observed as shown in Fig. 12.

Even if 0.1 wt.% of water is added to EIB75 at 90 °C, satisfactory aluminum corrosion resistance cannot be obtained because the total content of alcohols included in the fuel is as large as about 75 wt.%. When water is added in an amount of 0.2 wt.% that is a value exceeding 0.15 wt.% obtained by multiplying the total alcohol content by 0.002, satisfactory aluminum corrosion resistance is obtained. Further, satisfactory aluminum corrosion resistance at 120°C is obtained when water is added to 1.2 wt.% at 120°C. Thus, the addition of water is effective for the aluminum corrosion by dry

corrosion.

The result of addition of methanol instead of the water is shown in designation of formulation “EIB75-Me” of Fig. 12. In the case of addition of methanol, the aluminum corrosion resistance is improved in 1.5 wt.% addition, in which satisfactory aluminum corrosion resistance is obtained even at 100°C, and the low-temperature stability is also satisfactory. In 2.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the methanol without causing the layer separation at room temperature or at low temperature. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methanol in combination with water shown in “EIB75-Me” of Fig. 11, by mixing methanol with water, satisfactory aluminum corrosion preventive performance and satisfactory storage stability at room temperature and at low temperature can be obtained with a smaller content of methanol. Thus, the water has the effect of reducing the loading of methanol.

The result of addition of ethylene glycol as the glycols instead of the water is shown in designation of formulation “EIB75-EG” of Fig. 12. In the case of addition of ethylene glycol, the aluminum corrosion resistance is improved in 3.0 wt.%-addition, in which satisfactory aluminum corrosion resistance can be obtained even at 100°C, and the low-temperature stability is also satisfactory. In 5.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the ethylene glycol without causing the layer separation at room temperature or at low temperature. Thus, the ethylene glycol can

be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of ethylene glycol in combination with water shown in "EIB75-EG" of Fig. 12, by mixing ethylene glycol with water, satisfactory aluminum corrosion preventive performance and satisfactory storage stability at room temperature and at low temperature can be obtained with a smaller content of ethylene glycol. Accordingly, the water has the effect of reducing the loading of ethylene glycol.

The result of addition of methyl ethyl ketone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIB75-MEK" of Fig. 12. In the case of single addition of methyl ethyl ketone without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 3.0 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 5.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the methyl ethyl ketone can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl ethyl ketone in combination with water shown in "EIB75-MEK" of Fig. 12, by mixing methyl ethyl ketone with water, satisfactory aluminum corrosion preventive performance and satisfactory storage stability at room temperature and at low temperature can be obtained with a smaller content of methyl ethyl ketone. Accordingly, the water has the effect of reducing the loading of methyl ethyl ketone.

The result of single addition of methyl formate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIB75-GM" of Fig. 12. In the case of

single addition of methyl formate without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 4.0 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 8.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the methyl formate can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl formate in combination with water shown in "EIB75-GM" of Fig. 12, by mixing methyl formate with water, satisfactory aluminum corrosion preventive performance and satisfactory storage stability at room temperature and at low temperature can be obtained with a smaller content of methyl formate. Thus, the water has the effect of reducing the loading of methyl formate.

The result of single addition of acetaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIB75-AA" of Fig. 12. In the case of single addition of acetaldehyde without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.8 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 1.0 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature stability and the low-temperature stability in both the formulations. Thus, the acetaldehyde can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of acetaldehyde in combination with water shown in "EIB75-AA" of Fig. 12, by mixing acetaldehyde with water, satisfactory aluminum corrosion preventive performance and satisfactory storage stability at room temperature and at low temperature can be obtained with a smaller content of acetaldehyde.

Thus, the water has the effect of reducing the loading of acetaldehyde.

With respect to "EIB75-E" that is a basic formulation comprising ethers in addition to EIB75, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, ethylene glycol, methyl ethyl ketone, methyl formate, and acetaldehyde in the same manner as in the case of EIB75. The results are shown in Fig. 27. As is apparent from the results shown in Fig. 27, the same effect as in the case of EIB75 can be obtained also in the case of addition of ethers, and the water, methanol, ethylene glycol, methyl ethyl ketone, methyl formate and acetaldehyde can be effectively used also in those including ethers.

PNB30 that is Formation Example 10 has a basic composition composed of 70 wt.% of naphtha, 10 wt.% of isopropyl alcohol, 10 wt.% of n-butanol, and 10 wt.% of isobutyl alcohol, in which three kinds of alcohols are used.

When water is added to PNB30 to 0.1 wt.% at 80 °C, and to 1.8 wt.% at 120°C, the weight loss by aluminum corrosion is eliminated, as shown in Fig. 13, and the corrosion resistance is improved. However, the layer separation occurs in a storage property test at −10°C when water is added to 1.8 wt.%, with which no weight loss by aluminum corrosion occurs at 120°C, and the layer separation also occurs even at room temperature in 2.0 wt.%-addition of water, while those free from water or those with 0.1 wt.% of water have no problem for the storage property at −10°C that is low temperature. Accordingly, the addition of water is effective for the aluminum corrosion by dry corrosion, but the storage stability is deteriorated by the addition of water when it is intended to ensure satisfactory aluminum corrosion preventive performance also at 120°C that is high temperature by use of water.

The result of addition of methanol instead of the water is shown in

designation of formulation "PNB30-Me" of Fig. 13. In the case of addition of methanol, satisfactory aluminum corrosion resistance at 100°C is obtained in 1.0 wt.%-addition, and the low-temperature stability is also satisfactory therein. In 1.5 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the methanol without causing the layer separation at room temperature or at low temperature. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methanol in combination with water shown in "PNB30-Me" of Fig. 13, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding methanol. Thus, the methanol has the effect of reducing the loading of water and for improving the low-temperature stability.

The result of addition of ethylene glycol as the glycols instead of the water is shown in designation of formulation "PNB30-EG" of Fig. 13. In the case of addition of ethylene glycol, the aluminum corrosion resistance is improved in 2.0 wt.%, in which satisfactory aluminum corrosion resistance is obtained even at 100°C, and the low-temperature stability is also satisfactory. In 2.5 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the ethylene glycol without causing the layer separation at room temperature or at low

temperature. Thus, the ethylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of ethylene glycol in combination with water shown in "PNB30-EG" of Fig. 13, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the ethylene glycol has the effect of reducing the loading of water.

The result of addition of acetone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "PNB30-Ac" of Fig. 13. In the case of single addition of acetone without water, satisfactory aluminum corrosion resistances at 100°C and 120°C are obtained in 0.2 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability. Thus, the acetone can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of acetone in combination with water shown in "PNB30-Ac" of Fig. 13, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the acetone. Accordingly, the acetone is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of methyl formate as the esters instead

of the water and the result of addition thereof in combination with water are shown in designation of formulation "PNB30-GM" of Fig. 13. In the case of single addition of methyl formate without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 1.5 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 2.5 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature stability and the low-temperature stability in both the formulations. Thus, the methyl formate can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl formate in combination with water shown in "PNB30-GM" of Fig. 13, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the methyl formate. Accordingly, the methyl formate is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of butylaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "PNG30-BA" of Fig. 13. In the case of single addition of butylaldehyde without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.4 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 0.5 wt.%-addition. Further, satisfactory results are obtained for the normal-temperature stability and the low-temperature stability in both the formulations. Thus, the butylaldehyde can be satisfactorily used as the

aluminum corrosion inhibitor.

As is apparent from the result of addition of butylaldehyde in combination with water shown in "PNB30-BA" of Fig. 13, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the butylaldehyde has the effect of reducing the loading of water.

With respect to "PNB30-E" that is a basic formulation comprising ethers in addition to PNB30, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, ethylene glycol, acetone, methyl formate, and butylaldehyde in the same manner as in PNB30. The results are shown in Fig. 28. As is apparent from the results shown in Fig. 28, the same effect as in the case of PNB30 can be obtained also in the case of addition of ethers, and the water, methanol, ethylene glycol, acetone, methyl formate and butylaldehyde can be effectively used also in those including the ethers.

PNB15 that is Formation Example 11 has a basic composition composed of 85 wt.% of naphtha, 5 wt.% of isopropyl alcohol, 5 wt.% of n-butanol, and 5 wt.% of isobutyl alcohol, in which three kinds of alcohols are used with a smaller ratio. In PNB15, also, the same weight loss by aluminum corrosion by dry corrosion as in the other formulations is observed as shown in Fig. 14.

When water is added to PNB15 up to 0.1 wt.% at 80°C (treatment time 120 hours) and to 0.5 wt.% at 120°C (treatment time 24 hours), the weight loss by aluminum corrosion is eliminated, as shown in Fig. 14, and the corrosion resistance is improved. However, the layer separation occurs in a storage property test at −10°C when water is added to 0.5 wt.%, with

which no weight loss by aluminum corrosion occurs at 120°C, and the layer separation also occurs even at room temperature in 0.7 wt.%-addition of water, while those free from water or those with 0.1 wt.% of water have no problem for the storage property at −10°C that is low temperature. Accordingly, the addition of water is effective for the aluminum corrosion by dry corrosion, but the storage stability is deteriorated by the addition of water when it is intended to ensure satisfactory aluminum corrosion preventive performance also at 120°C that is high temperature by use of water.

The result of addition of methanol instead of the water is shown in designation of formulation "PNB15-Me" of Fig. 14. In the case of addition of methanol, the aluminum corrosion resistance is improved in 0.8 wt.%-addition, in which satisfactory aluminum corrosion resistance is obtained even at 100°C, and the low-temperature stability is also satisfactory. In 1.5 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the methanol without causing the layer separation at room temperature or at low temperature. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methanol in combination with water shown in "PNB15-Me" of Fig. 14, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the methanol. Accordingly, the

methanol is effective for reducing the loading of water and for improving the low-temperature stability.

The result of addition of propylene glycol as the glycols instead of the water is shown in designation of formulation "PNB15-PG" of Fig. 14. In the case of addition of propylene glycol, the aluminum corrosion resistance is improved in 3.0 wt.%-addition, in which satisfactory aluminum corrosion resistance is obtained even at 100°C, and the low-temperature stability is also satisfactory. In 4.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the propylene glycol without causing the layer separation at room temperature or at low temperature. Thus, the propylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of propylene glycol in combination with water shown in "PNB15-PG" of Fig. 14, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the propylene glycol has the effect of reducing the loading of water.

The result of addition of methyl-n-propyl ketone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "PNB15-MPK" of Fig. 14. In the case of single addition of methyl-n-propyl ketone without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.3 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 0.5 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the

formulations. Thus, the methyl-n-propyl ketone can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl-n-propyl ketone in combination with water shown in "PNB15-MPK" of Fig. 14, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the methyl-n-propyl ketone. Accordingly, the methyl-n-propyl ketone is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of methyl acetate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "PNB15-SM" of Fig. 14. In the case of single addition of methyl acetate without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 1.5 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 6.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the methyl acetate can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl acetate in combination with water shown in "PNB15-SM" of Fig. 14, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low

temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the methyl acetate. Accordingly, the methyl acetate is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of acetaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "PNB15-AA" of Fig. 14. In the case of single addition of acetaldehyde without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.3 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 0.5 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the acetaldehyde can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of acetaldehyde in combination with water shown in "PNB15-AA" of Fig. 14, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the acetaldehyde has the effect of reducing the loading of water.

With respect to "PNB15-E" that is a basic formulation comprising ethers in addition to PNB15, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, propylene glycol, methyl-n-propyl ketone, methyl acetate, and acetaldehyde in the same manner as in PNB15. The results are shown in Fig. 29. As is apparent from the results shown in Fig. 29, the same effect as in the case of

PNB15 can be obtained also in the case of addition of ethers, and the water, methanol, propylene glycol, methyl-n-propyl ketone, methyl acetate and acetaldehyde can be effectively used also in those including the ethers.

PNB75 that is Formation Example 12 has a basic composition composed of 25 wt.% of naphtha, 25 wt.% of isopropyl alcohol, 25 wt.% of n-butanol, and 25 wt.% of isobutyl alcohol, in which three kinds of alcohols are used with a high alcohol ratio.

Even if 0.1 wt.% of water is added to PNB75 at 80°C (treatment time 120 hours), satisfactory aluminum corrosion resistance cannot be obtained because the total content of alcohols included in the fuel is as large as about 75 wt.%. When water is added in an amount of 0.2 wt.% that is a value exceeding 0.15 wt.% obtained by multiplying the total alcohol content by 0.002, satisfactory aluminum corrosion resistance can be obtained. Further, satisfactory aluminum corrosion resistance at 120°C can be obtained when water is added, for example, to 10.0 wt.% at 120°C (treatment time 24 hours). However, the layer separation occurs in a low-temperature storage property test at −10°C when water is added to 10.0 wt.%, with which no weight loss by aluminum corrosion occurs at 120°C, and the layer separation also occurs even at room temperature in 10.5 wt.%-addition of water, while those free from water or those with 0.1 wt.% or 0.2 wt.% of water have no problem for the storage property at −10°C that is low temperature. Accordingly, the addition of water is effective for the aluminum corrosion by dry corrosion, but the storage stability is deteriorated by the addition of water when it is intended to ensure satisfactory aluminum corrosion preventive performance also at 120°C that is high temperature by use of water.

The result of addition of methanol instead of the water is shown in designation of formulation "PNB75-Me" of Fig. 15. In the case of addition of methanol, satisfactory aluminum corrosion resistance is obtained even at

100°C in 1.0 wt.%-addition, in which the low-temperature stability is also satisfactory. In 2.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the methanol without causing the layer separation at room temperature or at low temperature. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methanol in combination with water shown in "PNB75-Me" of Fig. 15, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the methanol. Accordingly, the methanol is effective for reducing the loading of water and for improving the low-temperature stability.

The result of addition of ethylene glycol as the glycols instead of the water is shown in designation of formulation "PNB75-EG" of Fig. 15. In the case of addition of ethylene glycol, the aluminum corrosion resistance is improved in 4.0 wt.%-addition, where satisfactory aluminum corrosion resistance can be obtained even at 100°C, and the low-temperature stability is also satisfactory. Further, in 6.0 wt.%-addition, a satisfactory result is obtained for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the ethylene glycol without causing the layer separation at room temperature or at low temperature. Thus, the ethylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of ethylene glycol in combination with water shown in "PNB75-EG" of Fig. 15, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the ethylene glycol has the effect of reducing the loading of water.

The result of addition of methyl ethyl ketone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "PNB75-MEK" of Fig. 15. In the case of single addition of methyl ethyl ketone without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.3 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 0.5 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the methyl ethyl ketone can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl ethyl ketone in combination with water shown in "PNB75-MEK" of Fig. 15, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the methyl ethyl ketone. Accordingly, the methyl ethyl ketone is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of ethyl formate as the esters instead of

the water and the result of addition thereof in combination with water are shown in designation of formulation "PNB75-GE" of Fig. 15. In the case of single addition of ethyl formate without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 4.0 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 6.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the ethyl formate can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of ethyl formate in combination with water shown in "PNB75-GE" of Fig. 15, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the ethyl formate. Accordingly, the ethyl formate is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of propionaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "PNB75-PA" of Fig. 15. In the case of single addition of propionaldehyde without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.3 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 0.5 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the propionaldehyde can be satisfactorily used as the

aluminum corrosion inhibitor.

As is apparent from the result of addition of propionaldehyde in combination with water shown in “PNB75-PA” of Fig. 15, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the propionaldehyde has the effect of reducing the loading of water.

With respect to “PNB75-E” that is a basic formulation comprising ethers in addition to PNB75, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, ethylene glycol, methyl ethyl ketone, ethyl formate, and propionaldehyde in the same manner as in the case of PNB75. The results are shown in Fig. 30. As is apparent from the results shown in Fig. 30, the same effect as in the case of PNB75 can be obtained also in the case of addition of ethers, and the water, methanol, ethylene glycol, methyl ethyl ketone, ethyl formate and propionaldehyde can be effectively used also in those including ethers.

EIPP30 that is Formation Example 13 has a basic composition composed of 70 wt.% of naphtha, 10 wt.% of ethanol, 10 wt.% of isopropyl alcohol, and 10 wt.% of 1-pentanol, in which the combination of kinds of alcohols is differed from that in PNB30.

When water is added to EIPP30 to 0.1 wt.% at 80°C (treatment time 120 hours) and to 2.5 wt.% at 120°C (treatment time 24 hours), for example, the weight loss by aluminum corrosion is eliminated, as shown in Fig. 16, and the corrosion resistance is improved. However, the layer separation occurs in a low-temperature storage property test at −10°C when water is added to 2.5 wt.%, with which no weight loss by aluminum corrosion occurs at 120°C, and the layer separation also occurs even at room temperature in

3.0 wt.%-addition of water, while those free from water or those with 0.1 wt.% of water have no problem for the storage property at −10°C that is low temperature. Accordingly, the addition of water is effective for the aluminum corrosion by dry corrosion, but the storage stability is deteriorated by the addition of water when it is intended to ensure satisfactory aluminum corrosion preventive performance also at 120°C that is high temperature by use of water.

The result of addition of methanol instead of the water is shown in designation of formulation "EIPP30-Me" of Fig. 16. In the case of addition of methanol, satisfactory aluminum corrosion resistance is obtained even at 100°C in 1.5 wt.%-addition, in which the low-temperature stability is also satisfactory. In 2.5 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the methanol without causing the layer separation at room temperature or at low temperature. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methanol in combination with water shown in "EIPP30-Me" of Fig. 16, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and low temperature of the resulting fuels. Accordingly, the methanol has the effect of reducing the loading of water.

The result of addition of ethylene glycol as the glycols instead of the water is shown in designation of formulation "EIPP30-EG" of Fig. 16. In the case of addition of ethylene glycol, the aluminum corrosion resistance is improved in 2.0 wt.%-addition, where satisfactory aluminum corrosion

resistance can be obtained even at 100°C, and the low-temperature stability is also satisfactory. In 5.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the ethylene glycol without causing the layer separation at room temperature or at low temperature. Thus, the ethylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of ethylene glycol in combination with water shown in "EIPP30-EG" of Fig. 16, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvement in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the ethylene glycol has the effect of reducing the loading of water.

The result of addition of acetone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIPP30-Ac" of Fig. 16. In the case of single addition of acetone without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 3.0 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 4.0 wt.%-addition. Further, satisfactory results are also obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the acetone can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of acetone in combination with water shown in "EIPP30-Ac" of Fig. 16, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the

resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the acetone. Accordingly, the acetone is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of methyl formate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation “EIPP30-GM” of Fig. 16. In the case of single addition of methyl formate without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 1.5 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 6.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the methyl formate can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl formate in combination with water shown in “EIPP30-GM” of Fig. 16, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the methyl formate. Accordingly, the methyl formate is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of butylaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation “EIPP30-BA” of Fig. 16. In

the case of single addition of butylaldehyde without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.6 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 1.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the butylaldehyde can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of butylaldehyde in combination with water shown in “EIPP30-BA” of Fig. 16, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the butylaldehyde has the effect of reducing the loading of water.

With respect to “EIPP30-E” that is a basic formulation comprising ethers in addition to EIPP30, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, ethylene glycol, acetone, methyl formate, and butylaldehyde in the same manner as in EIPP30. The results are shown in Fig. 31. As is apparent from the results shown in Fig. 31, the same effect as in the case of EIPP30 can be obtained also in the case of addition of ethers, and the water, methanol, ethylene glycol, acetone, methyl formate and butylaldehyde can be effectively used also in those including the ethers.

EIPP15 that is Formation Example 14 has a basic composition composed of 85 wt.% of naphtha, 5 wt.% of ethanol, 5 wt.% of isopropyl alcohol, and 5 wt.% of 1-pentanol, in which the combination of the kinds of alcohols is differed from that in the above PNB30, and the ratio is smaller than it.

When water is added to EIPP15 to 0.1 wt.% at 80°C (treatment time 120 hours) and to 0.8 wt.% at 120°C (treatment time 24 hours), the weight loss by aluminum corrosion is eliminated, as shown in Fig. 17, and the corrosion resistance is improved. However, the layer separation occurs in a low-temperature storage property test at −10°C when water is added to 0.8 wt.%, with which no weight loss by aluminum corrosion occurs at 120°C, and the layer separation also occurs even at room temperature in 1.0 wt.%-addition of water, while those free from water or those with 0.1 wt.% of water have no problem for the storage property at −10°C that is low temperature. Accordingly, the addition of water is effective for the aluminum corrosion by dry corrosion, but the storage stability is deteriorated by the addition of water when it is intended to ensure satisfactory aluminum corrosion preventive performance also at 120°C that is high temperature by use of water.

The result of addition of methanol instead of the water is shown in designation of formulation "EIPP15-Me" of Fig. 17. In the case of addition of methanol, the aluminum corrosion resistance is improved in 1.0 wt.%-addition, where satisfactory aluminum corrosion resistance can be obtained even at 100°C, and the low-temperature stability is also satisfactory. In 2.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C without causing the layer separation at room temperature or at low temperature, and the normal-temperature and low-temperature storage properties can be improved by adding the methanol without causing the layer separation at room temperature or at low temperature. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methanol in combination with water shown in "EIPP15-Me" of Fig. 17, satisfactory aluminum

corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in room-temperature and low-temperature storage stability of the resulting fuels. Accordingly, the methanol has the effect of reducing the loading of water.

The result of addition of propylene glycol as the glycols instead of the water is shown in designation of formulation "EIPP15-PG" of Fig. 17. In the case of addition of propylene glycol, the aluminum corrosion resistance is improved in 2.5 wt.%-addition, in which satisfactory aluminum corrosion resistance can be obtained even at 100°C, and the low-temperature stability is also satisfactory. In 4.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the propylene glycol without causing the layer separation at room temperature or at low temperature. Thus, the propylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of propylene glycol in combination with water shown in "EIPP15-PG" of Fig. 17, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in room-temperature and low-temperature storage stability of the resulting fuels. Accordingly, the propylene glycol has the effect of reducing the loading of water.

The result of addition of diethyl ketone as the ketones instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIPP15-DEK" of Fig. 17. In the case of single addition of diethyl ketone without water, satisfactory aluminum corrosion

resistance at 100°C is obtained in 2.0 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 3.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the diethyl ketone can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of diethyl ketone in combination with water shown in "EIPP15-DEK" of Fig. 17, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in room-temperature and low-temperature storage stability of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the diethyl ketone. Accordingly, the diethyl ketone is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of methyl acetate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIPP15-SM" of Fig. 14. In the case of single addition of methyl acetate without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 1.2 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 4.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the methyl acetate can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl acetate in combination with water shown in "EIPP15-SM" of Fig. 17, satisfactory aluminum corrosion preventive performance can be ensured even if the

loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Further, when water is added in the same loading as in the addition of water per se, the low-temperature stability of the resulting liquid fuels can be improved by further adding the methyl acetate. Accordingly, the methyl acetate is effective for reducing the loading of water and for improving the low-temperature stability.

The result of single addition of propionaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIPP15-PA" of Fig. 14. In the case of single addition of propionaldehyde without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.5 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 0.8 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the propionaldehyde can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of propionaldehyde in combination with water shown in "EIPP15-PA" of Fig. 17, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the propionaldehyde has the effect of reducing the loading of water.

With respect to "EIPP15-E" that is a basic formulation comprising ethers in addition to EIPP15, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, propylene glycol, diethyl ketone, methyl acetate, and propionaldehyde in the same

manner as in EIPP15. The results are shown in Fig. 32. As is apparent from the results shown in Fig. 32, the same effect as in the case of EIPP15 can be obtained also in the case of addition of ethers, and the water, methanol, propylene glycol, diethyl ketone, methyl acetate and propionaldehyde can be effectively used also in those including the ethers.

EIPP75 that is Formation Example 15 has a basic composition composed of 25 wt.% of naphtha, 25 wt.% of ethanol, 25 wt.% of isopropyl alcohol, and 25 wt.% of 1-pentanol, in which three kinds of alcohols different from those in the PNB 75 are used in a high alcohol ratio. In EIPP75, also, the same weight loss by aluminum corrosion by dry corrosion as in the case of EIPP15 is observed as shown in Fig. 18.

Even if 0.1 wt.% of water is added to EIPP75 at 80°C (treatment time 120 hours), satisfactory aluminum corrosion resistance cannot be obtained because the total content of alcohols included in the fuel is as large as about 75 wt.%, as shown in Fig. 18. When water is added in an amount of 0.2 wt.% that is a value exceeding 0.15 wt.% obtained by multiplying the total alcohol content by 0.002, satisfactory aluminum corrosion resistance can be obtained. Further, at a temperature of 120°C, satisfactory aluminum corrosion resistance at 120°C can be obtained when water is added to 1.7 wt%. Thus, the addition of water is effective for the aluminum corrosion by dry corrosion.

The result of addition of methanol instead of the water is shown in designation of formulation "EIPP75-Me" of Fig. 18. In the case of addition of methanol, the aluminum corrosion resistance is improved in 2.0 wt.% addition, in which satisfactory aluminum corrosion resistance can be obtained even at 100°C, and the low-temperature stability is also satisfactory. In 3.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and

low-temperature storage properties can be improved by adding the methanol without causing the layer separation at room temperature or at low temperature. Thus, the methanol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methanol in combination with water shown in "EIPP75-Me" of Fig. 18, by mixing methanol with water, satisfactory aluminum corrosion preventive performance and satisfactory storage stability at room temperature and at low temperature can be obtained with a smaller content of methanol. Accordingly, the water is effective for reducing the loading of methanol.

The result of addition of ethylene glycol as the glycols instead of the water is shown in designation of formulation "EIPP75-EG" of Fig. 18. In the case of addition of ethylene glycol, the aluminum corrosion resistance is improved in 4.0 wt.%-addition, where satisfactory aluminum corrosion resistance can be obtained even at 100°C, and the low-temperature stability is also satisfactory. Further, in 8.0 wt.%-addition, a satisfactory result is obtained also for the aluminum corrosion resistance at 120°C, and the normal-temperature and low-temperature storage properties can be improved by adding the ethylene glycol without causing the layer separation at room temperature or at low temperature. Thus, the ethylene glycol can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of ethylene glycol in combination with water shown in "EIPP75-EG" of Fig. 18, by mixing ethylene glycol with water, satisfactory aluminum corrosion preventive performance and satisfactory storage stability at room temperature and at low temperature can be obtained with a smaller content of ethylene glycol. Accordingly, the water is effective for reducing the loading of ethylene glycol.

The result of addition of methyl ethyl ketone as the ketones instead

of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIPP75-MEK" of Fig. 18. In the case of single addition of methyl ethyl ketone without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 3.0 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 5.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the methyl ethyl ketone can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl ethyl ketone in combination with water shown in "EIPP75-MEK" of Fig. 18, by mixing methyl ethyl ketone with water, satisfactory aluminum corrosion preventive performance and satisfactory storage stability at room temperature and at low temperature can be obtained with a smaller content of methyl ethyl ketone. Accordingly, the water is effective for reducing the loading of methyl ethyl ketone.

The result of single addition of methyl formate as the esters instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIPP75-GM" of Fig. 18. In the case of single addition of methyl formate without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 3.0 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 9.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the methyl formate can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of methyl formate in combination with water shown in "EIPP75-GM" of Fig. 18, by mixing methyl

formate with water, satisfactory aluminum corrosion preventive performance and satisfactory storage stability at room temperature and at low temperature can be obtained with a smaller content of methyl formate. Accordingly, the water is effective for reducing the loading of methyl formate.

The result of single addition of acetaldehyde as the aldehydes instead of the water and the result of addition thereof in combination with water are shown in designation of formulation "EIPP75-AA" of Fig. 15. In the case of single addition of acetaldehyde without water, satisfactory aluminum corrosion resistance at 100°C is obtained in 0.5 wt.%-addition, and satisfactory aluminum corrosion resistance at 120°C is obtained in 1.0 wt.%-addition. Further, satisfactory results are obtained for normal-temperature stability and low-temperature stability in both the formulations. Thus, the acetaldehyde can be satisfactorily used as the aluminum corrosion inhibitor.

As is apparent from the result of addition of acetaldehyde in combination with water shown in "EIPP75-AA" of Fig. 18, satisfactory aluminum corrosion preventive performance can be ensured even if the loading of water is reduced, and this reduction in loading of water can lead to improvements in storage stability at room temperature and at low temperature of the resulting fuels. Accordingly, the acetaldehyde has the effect of reducing the loading of water.

With respect to "EIPP75-E" that is a basic formulation comprising ethers in addition to EIPP75, tests for aluminum corrosion resistance and storage stability were carried out by adding water, methanol, ethylene glycol, methyl ethyl ketone, methyl formate, and acetaldehyde in the same manner as in the case of EIPP75. The results are shown in Fig. 33. As is apparent from the results shown in Fig. 33, the same effect as in the case of EIPP75 can be obtained also in the addition of ethers, and the water, methanol,

ethylene glycol, methyl ethyl ketone, methyl formate and acetaldehyde can be effectively used also in those including ethers.

The working examples of the present invention are described above based on Figs. 4 to 34. The additive effects of water and each aluminum corrosion inhibitor in each formulation are summarized in Fig. 35.

As shown in Fig. 35, the use of methanol, glycols, ketones, esters, and aldehydes as the aluminum corrosion inhibitor can provide either the effect of preventing the aluminum corrosion by single addition or the effect of improving the storage stability by the reducing effect by the added water and the reduction in the loading of water. Accordingly, by using these materials, fuels more excellent in aluminum corrosion preventive performance and more stable in storage stability can be obtained.

Further, the aluminum corrosion preventive effect can be confirmed in all the formations by adding water, which shows that the addition of water is effective for preventing the aluminum corrosion.

With respect to the amount of water to be added, as shown in the examples of water addition in Formulation Examples 0 to 15, the effect on corrosion at 80°C or the like that is low temperature can be ensured by adding 0.1 wt.% or more of water in an area with low alcohol ratio where the ratio of alcohols contained in the resulting liquid fuel is less than 50 wt.%. However, the weight loss by corrosion cannot be prevented by 0.1 wt.%-addition of water in some cases, when the alcohol ratio is 50 wt.% or more, as shown in IN75, EIB75, PNB75, and EIPP75, while the weight loss by corrosion can be prevented by 0.2 wt.% addition of water. From this fact, it is conceivable that the lowest loading of water according to the alcohol ratio is present between 0.1 wt.% and 0.2 wt.% when the alcohol ratio is 50 wt.% or more. Therefore, the verification test shown in Fig. 37 was carried out.

In this verification test, as shown in Fig. 37, the formulation IPB75

composed of 25 wt.% of naphtha, 35 wt.% of isopropyl alcohol, and 35 wt.% of isobutyl alcohol was used, and the aluminum corrosion test was carried out while changing the loading of water by 0.05 wt.%.

In the result, as shown in Fig. 37, the weight loss by corrosion occurs similarly to the cases of IN75, EIB75, PNB75, and EIPP75 in 0.1-wt.%-addition of water, the amount corresponding to 0.13% to 75 wt.% that is the alcohol ratio, while no weight loss by corrosion occurs in 0.15 wt.%-addition of water, the amount corresponding to 0.2 % (=weight ratio×0.002) to 75 wt.% that is the alcohol ratio. Accordingly, when the alcohol ratio is 50 wt.% or more, water can be added in an amount of 0.2% (=weight ratio×0.002) or more to the alcohol ratio.

The upper limit of the amount of water to be added can be set to a minimum amount capable of providing the aluminum corrosion preventive effect, based on the using environment of the resulting fuel or the like, because addition of water per se causes the deterioration of low-temperature stability or room-temperature stability as described above.

Although preferred embodiments of the present invention are described by the above-mentioned working examples, the present invention is not restrictive to these examples. Various changes or additions within the meaning and range of equivalency of the claims, or addition of other raw fuels or additives (including metal and the like) within the range never significantly changing the characteristics of the fuel for internal combustion engine of the present invention can be optionally made, and it will be obvious to those skilled in the art that the resulting fuels for internal combustion engine may be included in the present invention.

In the above working examples, gasoline fuel is mainly described, but the present invention is not restrictive to the gasoline fuel, but applicable to other internal combustion engines using diesel fuel and the like.